A WEB-BASED EMERGENCY RESPONSE SYSTEMS FOR LIGHTS OUT OPERATIONS

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ABSTRACT

The ultimate goal of "lights out" mission operations is to significantly reduce the cost of operating spacecraft. Although autonomous systems will become the norm, ground system autonomy will not reach its full potential until the new operations software is not only functional, but also cost effective and secure. This is particularly true for fault management software. When anomalies occur during lights out operations, it is imperative that the software (1) log all relevant information, (2) notify the appropriate Flight Operations Team (FOT) members in a timely manner, (3) provide tools for a remote and distributed FOT to resolve the anomaly, and (4) insure secure and appropriate access to the data.

To meet these demands, NASA Goddard's Code 588 (Advanced Architectures and Autonomy Branch) is building the Spacecraft Emergency Response System (SERS). SERS is a Web-based collaborative environment that enables secure distributed fault management. SERS is part of Code 588's Virtual Mission Operations Center (VMOC) project [1] [2].

Keywords: Mission operations, autonomy, groupware, World-Wide Web, SERS

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1. INTRODUCTION

SERS is a comprehensive and sophisticated emergency management system. It goes well beyond the current generation of alert/paging systems that simply broadcasts a numeric page to one or two default operators without knowing whether or not the operator(s) receive the alert. Instead, SERS provides automated logging and report generation; on-line staff scheduling and resource management; access to on-line documentation, telemetry, and mnemonics; and manipulation of filters used to trigger response events and emergency notification.

However, what makes SERS truly unique is that SERS provides intelligent 2-way communications. SERS analyzes operational log files (e.g., like those generated by ITOS™) or diagnoses from expert systems (e.g., Altair™) to determine who is the proper team member(s) to contact (based on skills and schedules). SERS sends alert notification to the team members via the appropriate media (pager, telephone, or e-mail), depending on the level of severity of the alert and the type of communications device that person possesses.

After sending alert notifications, SERS monitors for team members' responses. If an alert notification is sent via SkyTel's 2-Way paging network, the team member will receive an alphanumeric page that contains background information on the alert, as well as three options to reply back to SERS: (1) ask for more information; (2) defer responsibility to a backup; or (3) accept responsibility. Similarly, SERS can call a team member on the telephone, read the alert notification (via a text-to-speech engine) and allow the operator to reply to the alert notification via keys on the telephone. E-mail alerts contain the same alert information, with the addition of a URL link to the appropriate SERS report. Based upon the responses to the alert notifications, SERS will identify and alert backup team members as necessary.

All this functionality is unified under a common Web-based, user-friendly graphical user interface. Users have point-and-click access to their operational information (e.g., event logs and mnemonics), historical information (e.g., I&T databases) and utilities (e.g., configuration files and tools). Extensive effort has been dedicated to developing a suite of tools that are not only functional, but also highly usable. The software has been developed in a user-centered manner through extensive prototyping, user evaluations, and independent usability reviews [3].

2. COST EFFECTIVENESS

To make the SERS cost effective, the software is primarily built with a commercial off the shelf (COTS) database management system called Lotus Domino™ (formerly called Lotus Notes™). Domino is a groupware package that provides the capability to rapidly develop sophisticated Web-based software that incorporates intelligent agents, threaded discussions, workflow, database connectivity, and links to communications gateways (e.g., 2-way paging and telephony). Because Domino applications are built using a fourth-generation language (LotusScript™), applications can easily be tailored and reused across missions. Domino also provides easy integration with JavaScript (used in SERS to add more interactivity) and Java.

In addition, Domino provides user access via a client-server model (through the Lotus Notes client) and via a Web thin client interface (i.e., through a browser). Browser access reduces the costs associated with software procurement, maintenance, and training. This approach also reduces costs by allowing the FOT to access data from any computer with a Web browser (Netscape™ 3 or Internet Explorer™ 4 or later). However, mission personnel are expected to almost exclusively use a Web browser to access SERS. Thus, SERS has been optimized for Web access. A black & white screen capture of a SERS

display from the Events database is shown in Figure 1. The Events database logs incoming spacecraft and ground events (e.g., anomalous conditions) and their associated notifications.

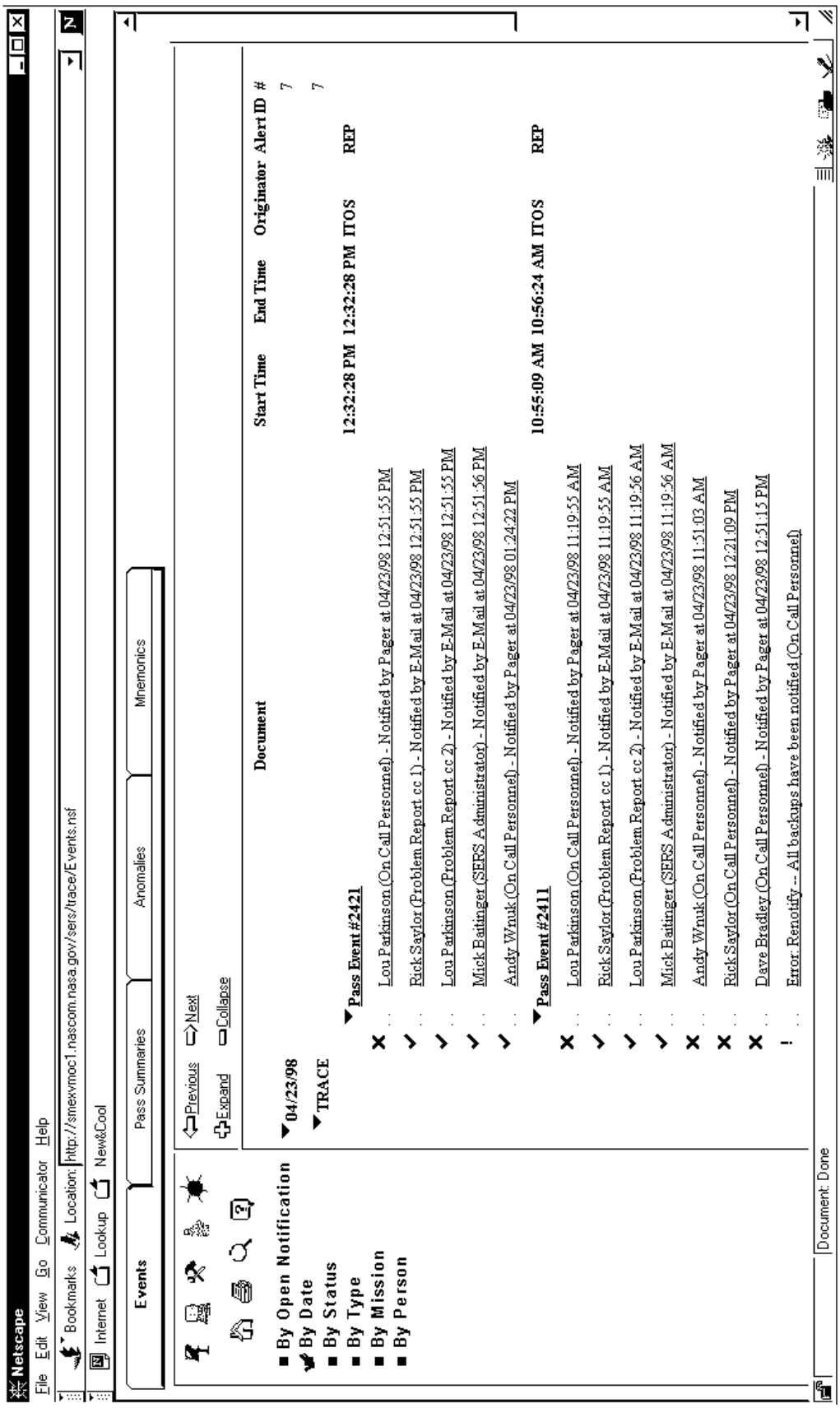

Figure 1: The Main Workspace for SERS' Event Database

Another factor that makes SERS cost effective is its simple and flexible communications interface. A SERS server is configured to receive anomaly information through e-mail from ground systems. The e-mail connection between ground systems and the SERS server is accomplished by a direct SMTP linkage so that SERS can remain independent from the LAN/WAN mail routers. An e-mail interface is used because:

- For security reasons, ground station computers generally are located behind the firewall. However, the SERS server must reside outside the firewall so that information can be viewed from the Internet. The easiest way to send messages across the firewall is through e-mail.

- E-mail is a universal application regardless of the types of hardware, the operating systems, or the ground systems. As long as e-mail can be sent, the SERS server can be reached.

For more information on how SERS message formatting see the SERS 1.0 Users Manual [4].

3. SECURITY AND RELIABILITY

SERS provides a high level of security. Domino supports encryption with Secure Socket Layer (SSL), digital signatures, and password protection. SERS authenticates users via passwords to limit access and the tailor functionality based on the privileges assigned to the user (e.g., operator, engineer, manager, etc.). The permission level determines what the user can access and edit. Domino provides easy mechanisms to limit who can:

- Access a database
- View (open) forms within a database
- View and/or edit individual fields within a form

Using this capability not only protects data from unauthorized access, but also increases the overall usability of the software by dynamically determining and presenting only the information that is relevant to the user. To enhance reliability, the standard SERS setup consists of prime and backup servers. A full version of the SERS software is active on both servers. Using Domino's Advance Services™ option, the two copies of the application continuously replicate data to ensure that no data is lost should one of the copies of SERS stop functioning. Likewise, there is a pager gateway on each machine so that emergency notifications will be sent to the on-call operators. On the prime machine, pages are sent to SkyTel via the Internet. On the backup machine, pages are sent to Skytel via an analog line. Agents on each machine monitor the status of both machines and the pager gateways. Should an agent detect a problem on one machine, the other machine's agent takes over. Also, a notice is sent to the administrator describing the problem. The SERS configuration for the TRACE (Transition Region and Coronal Explorer) mission is shown in Figure 2.

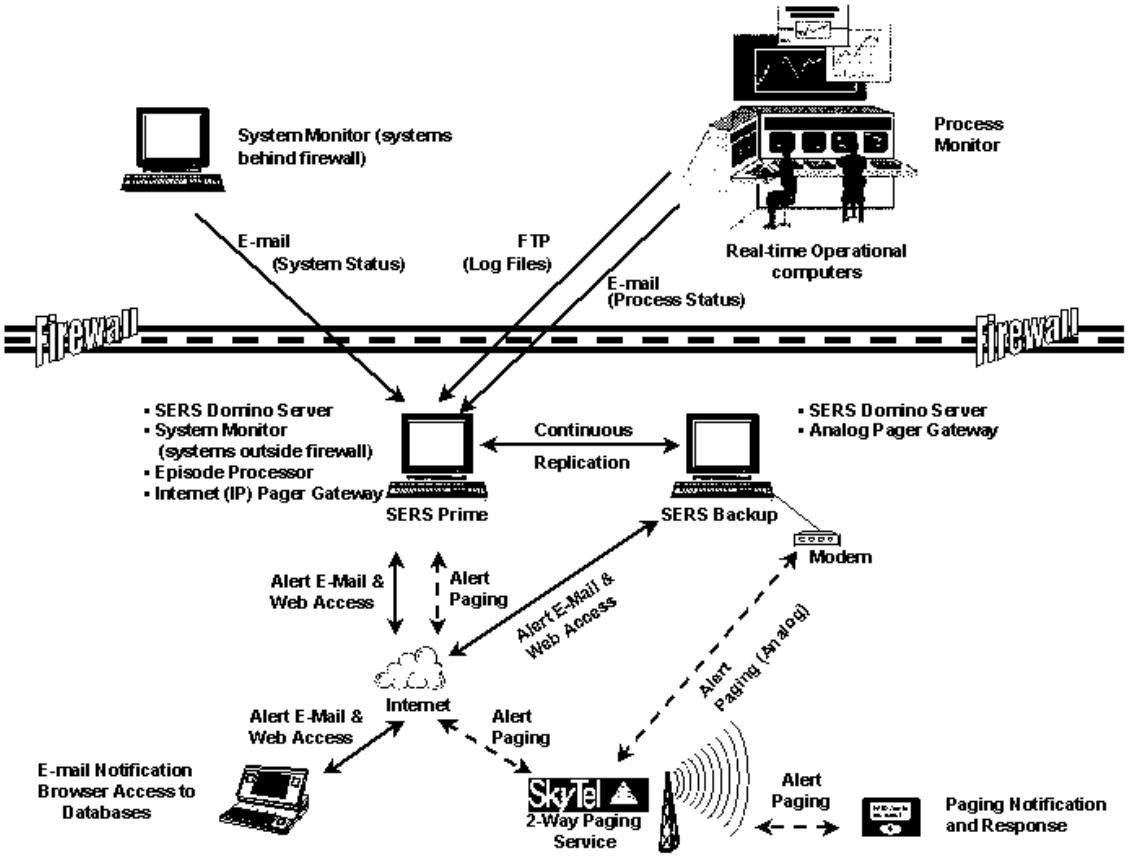

Figure 2: SERS Configuration for the TRACE Mission

SERS also has system and process monitors that check the status of other (non-SERS) mission computers as well as the network's link to the Internet. Again, notifications are sent to the appropriate people if problems are detected. In the case of a network problem that involves losing connectivity to the Internet, a notification will be sent to the administrator's pager via a dial-up analog line. As with Spacecraft events, problems with the network or computers on that network are logged by SERS in a Web-viewable report.

4. DEPLOYMENT OF SERS

In the fall of 1997, a subset of the SERS was used successfully by TRACE for Integration & Test. On April 1, 1998, SERS was first used in an operational setting by TRACE. SERS will also be used for the MIDEX missions, as well as the Navy SAIL program.

5. REFERENCES

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